Diagnosis and Management of Suspected Acute Cholecystitis in the Emergent Setting: Current Concepts

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Learning objectives

Ultrasound has been the main modality for diagnosis of suspected acute cholecystitis in the emergent setting. With increasing availability and speed of cross sectional imaging, new methods of diagnosis and management are being utilized. Understanding the benefits and limitations of each modality is essential for appropriate use in the emergent setting.

We propose the following learning objectives:

• Review the current imaging algorithm used in the emergent setting for suspected acute cholecystitis.

• Identify the available modalities of imaging to aid in diagnosis and identification of complications associated with acute cholecystitis.

• Review the benefits and limitations of each modality in the emergent setting, with emphasis on appropriate use for each modality through case examples.

• Illustrate new concepts emerging in diagnosis and management in the emergent setting, specifically, the role of magnetic resonance imaging.
Background

Acute abdominal pain is a very common emergency room complaint and accounts for 5-10% of all emergency room visits [1]. Acute cholecystitis is one of the differential diagnoses when working up acute abdominal pain, particularly right upper quadrant pain. Imaging is essential for diagnosis and ultrasound is often the initial screening examination.

Approximately 10-15% of people in the Western hemisphere have cholelithiasis [2]. 90-95% of cases of acute cholecystitis are associated with cholelithiasis causing obstruction of the cystic duct or gallbladder neck [3]. Quick, accurate diagnosis is essential to prevent complications, which develop when increased intraluminal pressure prevents arterial perfusion causing mural ischemia, necrosis, and ultimately perforation [3].

Complicated acute cholecystitis includes:

- Gangrenous cholecystitis
- Emphysematous cholecystitis
- Acute suppurative cholangitis

Current Algorithm for Acute Abdominal Pain in the Emergent Setting [1]:

- There is variation within and between hospitals on the imaging algorithm used to evaluate acute abdominal pain.
- Increasing trend toward use of Computed Tomography (CT).
- New concerns being raised with regards to: Cost effectiveness, over utilization and appropriateness of imaging, radiation, and patient throughput.
- For acute right upper quadrant pain, especially of a biliary colic nature, ultrasound is the initial modality of choice.
- There is a lack of evidence published as to the next imaging modality to use in the emergent setting when ultrasound is equivocal or negative.

Diagnosis:

The Tokyo criteria was established to attempt to standardize the diagnosis and severity of acute cholecystitis [2].

Definite diagnosis can be made in the following two scenarios [2]:

- Acute cholecystitis
- Acute suppurative cholangitis
1. One local sign of inflammation (Murphy’s sign or RUQ pain) and one systemic sign of inflammation (fever, elevated C-reactive protein, leukocytosis).

2. Imaging findings that are characteristic for diagnosis in a patient clinically suspected to have acute cholecystitis (Including thickened gallbladder wall or enlarged gallbladder on US, MRI, or CT), sonographic Murphy’s sign, pericholecystic fluid on US or CT, or pericholecystic high signal intensity on MRI.

Tokyo criteria are not widely accepted. The signs of acute cholecystitis which are widely accepted include:

**Signs of acute cholecystitis [3]**

- Gallbladder distention
- Sludge or gallstones
- Mural thickening with wall edema and hypervascularization
- Pericholecystic fluid
- Positive Murphy’s sign

Ultrasound diagnostic sensitivity and specificity reported shown a wide range and these numbers may be outdated since they do not account for improvements in technology over time. Shea et al. reported HIDA scan to have the best sensitivity and ultrasound to have a 88% sensitivity and 80% specificity [2].
Imaging findings OR Procedure details

ULTRASOUND:

• Ultrasound is widely accepted as the initial imaging test to evaluate right upper quadrant pain.

Classic Imaging Findings [4, 5]: (Fig 1. and Fig 2.)

<table>
<thead>
<tr>
<th>Finding</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Luminal distention</td>
<td>&gt;5 cm in transverse dimension and &gt; 10 cm in longitudinal dimension</td>
</tr>
<tr>
<td>Gallstones or sludge</td>
<td></td>
</tr>
<tr>
<td>Wall thickening</td>
<td>&gt;3 cm</td>
</tr>
<tr>
<td>Wall hyperemia</td>
<td>Increased vascularity on Doppler imaging</td>
</tr>
<tr>
<td>Positive sonographic Murphy's sign</td>
<td>Pain provoked by the transducer in the exact area of the gallbladder, which is the same as the spontaneous pain they report, that causes cessation of breathing</td>
</tr>
</tbody>
</table>

Murphy’s sign has been reported to be the most reliable and sensitive indicator, however, this applies only when it is performed and interpreted correctly. In addition, the administration of pain medication may provide false negative results [5].

BENEFITS LIMITATIONS

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Limitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Widely available</td>
<td>Variable sensitivities and specificities</td>
</tr>
<tr>
<td>Quick real time results</td>
<td>Unreliable detection of cystic duct and common bile duct stones</td>
</tr>
<tr>
<td>Non-invasive</td>
<td>Accuracy is dependent on the performer, experience of the interpreter, patient cooperation, and patient body habitus</td>
</tr>
<tr>
<td>Inexpensive</td>
<td>Poor accuracy at detecting complications</td>
</tr>
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</table>

Sensitivity for detecting gallbladder inflammation ranges from 37.5-91% and specificity has a range of 60-100% [3].
Choledocholithiasis is present in 10-15% of acute cholecystitis cases and a 38% sensitivity is reported for ultrasound detection of cystic duct and common bile duct stones. Choledocholithiasis is suggested when the common bile duct measures >8mm [3].

**COMPUTED TOMOGRAPHY (CT):**

- Widely used in the emergent setting to evaluate causes of abdominal pain and to further investigate right upper quadrant pain when ultrasound is negative or equivocal [3].
- Similar specificity, but higher sensitivity (83% vs 39%) compared to ultrasound [3].
- CT also has higher positive (75 vs. 50%) and negative (97 vs. 89%) predictive values compared to ultrasound [3].

**Imaging findings most consistent with acute cholecystitis (Fig 3):**

- Gallbladder over distention
- Mural thickening with mucosal hyperenhancement
- Pericholecystic fat stranding or fluid
- Pericholecystic liver enhancement

[3]

**BENEFITS LIMITATIONS**

- Detect other causes of abdominal pain
- Unreliable detection of gallstones (Fig. 4)
- Assess complications of acute cholecystitis
- Underestimates wall thickness
- Best modality to detect gangrenous cholecystitis (Fig. 5)
- Exposure to radiation
- Improved visualization of the biliary ductal system (sensitivity 70-80%)
- Exposure to intravenous contrast
- Cannot assess for Murphy’s sign

[3,5]

**HIDA:**

- Highest diagnostic accuracy of all imaging modalities with a sensitivity of 96% and specificity of 90% [2].
Imaging finding diagnostic of acute cholecystitis:

- Nonvisualization of the gallbladder with visualization of radiotracer in the duodenum and small bowel. In normal cases the gallbladder should fill with tracer in 30 minutes [5]. (Fig. 6)

**BENEFITS LIMITATIONS**

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Limitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most accurate diagnosis</td>
<td>Lack of availability of technologists</td>
</tr>
<tr>
<td>Highest sensitivity and specificity</td>
<td>Exam takes a significant amount of time to perform</td>
</tr>
<tr>
<td></td>
<td>Information limited to the biliary tract</td>
</tr>
<tr>
<td></td>
<td>Exposure to radiation</td>
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<tr>
<td></td>
<td>Chronic cholecystitis, pancreatitis, hyperalimentation, or absence of fasting can cause false positives</td>
</tr>
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</table>

[2,5]

**MAGNETIC RESONANCE IMAGING (MRI):**

- Best soft tissue contrast. (2)
- Literature has shown that MRI and MRCP within 24 hours of an emergent admission is useful to detect acute biliary abnormalities, specifically in patients with equivocal results from other imaging studies or persistent clinical suspicion [2].
- Provides additional diagnostic value when ultrasound is equivocal or negative and there is persistent clinical concern.
- Choledocholithiasis is present in 10-15% of cases of acute cholecystitis. MRI provides a noninvasive means of analyzing the biliary system with a sensitivity of 89-100% and specificity of 83-100% detection, compared to 38% sensitivity on ultrasound [2].
- Valuable for pre-operative planning as well as diagnosis: Assess need for pre-operative percutaneous cholecystostomy tube drainage, need for ERCP, and identification of biliary anomalies or unusual anatomy [2].

**Imaging Findings consistent with acute cholecystitis:**

- MRI shows **gallbladder sludge and stones as**: T1 hyperintense sediment and hypointense foci, respectively, often impacted in the neck or cystic duct with acute cholecystitis [6].
**IMAGING FINDINGS consistent with acute cholecystitis:**

Gallbladder distention transverse dimension $\geq$ 4 cm
Wall thickening $> 3$ mm
T2 hyper-intensity within the wall represents mural inflammation
T2 hyperintense pericholecystic and perihepatic fluid
C sign: small amount of fluid between the liver and right hemidiaphragm
Choledocholithiasis seen as filling defects within the biliary ducts
Hyperenhancement on post contrast imaging can be seen in the gallbladder wall, pericholecystic fat, and pericholecystic liver parenchyma

[2,6]

- The presence of one or more of the previously described findings has a sensitivity of 88% and specificity of 89% for detection of acute cholecystitis [6].
- Findings suggestive of intramural necrosis, micro abscesses, and hemorrhage include: marked, irregular, or asymmetric mural thickening, abnormal hyperintense signal within or adjacent to the wall, inhomogeneous or absent contrast wall enhancement, perforation with wall disruption and possible pericholecystic fluid collection [2].
- Of note a thickened gallbladder wall may be seen in many other chronic conditions and is a potential pitfall. A diffuse or patchy appearance of wall thickening may suggest an acute process [6].

**LIMITATIONS BENEFITS**

<table>
<thead>
<tr>
<th>High cost</th>
<th>Identification of complications from acute cholecystitis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Previously lack of MRI machine and technologists was a limitation</td>
<td>Detection of findings suggestive of intramural necrosis, micro abscesses, and hemorrhage</td>
</tr>
<tr>
<td>Previously long duration of sequences</td>
<td>No ionizing radiation or exposure to CT contrast</td>
</tr>
<tr>
<td>Contraindicated in persons with cardiac devices, certain metallic implants or foreign bodies, and other incompatible devices</td>
<td>Provides specific information about causes, extent of inflammation, presence or absence of necrosis and abscess, and</td>
</tr>
</tbody>
</table>
Limited use in uncooperative or claustrophobic patients, as well as severely ill.

Decreased accuracy of detection of CBD stones when \( < \) or equal to 3 mm

[2]

**EMERGING CONCEPTS IN MRI:**

Changes in availability, technology, contrast agents, radiation awareness, costs, and other associated benefits have made MRI a more accessible imaging modality to use in the emergent setting.

**Imaging technology:**

- Faster acquisition and shortened protocols with use of phase array coils [2].
- Sequences selected for emergent imaging should be tailored to the acute problem and aim to decrease acquisition time as much as possible and still provide diagnostic information [4].
- Protocols differ between facilities but there are many common sequences used.
- Respiratory triggered imaging vs. breath hold preferred in acute patients [4].
- T1-weighted gradient echo/fast field echo, T2-weighted turbo spin echo, fluid sensitive sequence, fat suppressed T2-weighted turbo spin echo, or short tau inversion recovery, heavily weighted T2-weighted MRCP with suppressed background (thick and thin slab if possible).
- Use of contrast enhanced imaging is optional because many acute conditions involving inflammation, edema, and structural derangements can be seen on fluid sensitive imaging sequences [4].
- More sensitive for detection of findings of acute cholecystitis, which may not be recognized on other imaging modalities.

Our facility includes the following sequences for emergent abdominal imaging for suspected acute cholecystitis:

- T1W gradient echo in and out of phase
- T2W single shot turbo spin echo
- T2W fat suppressed turbo spin echo

Axial, breath hold
Axial and coronal, breath hold
Axial, respiratory triggered
Advances in contrast agents:

Some studies have shown positive results using Gd-BOPTA enhanced, and more recently Eovist enhanced MR cholangiography to provide functional imaging similar to HIDA [7,8].

- These are hepatobiliary contrast agents and work by shortening the T1-relaxation times. They differ from gadolinium based agents because they accumulate within the hepatocytes and are later excreted in bile [8].
- Gd-BOPTA (also known as MultiHance) is excreted to a lesser degree by the bile ducts compared to Eovist and due to its smaller percentage of biliary excretion, delayed imaging needs to be performed between 45 min to 3 hours [8].
- Eovist behaves as an extracellular agent on early dynamic imaging, but also possesses a hepatocyte-selective profile, and is accumulated in the liver and biliary system on delayed imaging at only 20 min, making it more desirable for the emergent setting [9].
- Lack of these hepatobiliary contrast agents seen within the gallbladder on an exam is suggestive of an obstructed cystic duct and acute cholecystitis, although further research is needed [8].

Allows for pre-operative planning: which may or may not change surgical approach or pre-operative decisions.

Further Research:

- Now that MRI has become increasingly used in the emergent setting further studies, particularly with larger sample sizes and head to head comparison with other modalities, is needed to determine better accuracy estimates for diagnosis of acute cholecystitis [2].
- In addition, more studies using hepatobiliary contrast agents need to be performed to determine the diagnostic ability of these agents for acute cholecystitis.

CASE EXAMPLES:

Fig 7.
Fig. 7: A. Ultrasound image of a distended gallbladder, not suspicious for acute cholecystitis. B. Axial T2W MRI image of the same patient with obvious pericholecystic fluid showing acute cholecystitis.

References: Radiology, Boston Medical Center - Boston/US

Fig 8.
Fig. 8: A. US image showing an unremarkable gallbladder. B, C. Coronal and axial contrast enhanced CT images showing a distended gallbladder with mild surrounding pericholecystic fat stranding, consistent with acute cholecystitis. D. AP HIDA image with non visualization of the gallbladder diagnostic of acute cholecystitis.

References: Radiology, Boston Medical Center - Boston/US

Fig 9.
**Fig. 9:** A. US image of dependent sludge within a nondistended gallbladder, which is otherwise unremarkable. B. Coronal T2TSE showing pericholecystic fluid, C and D. axial T2 fat sat images showing pericholecystitic fluid and gallstone, consistent with acute cholecystitis.

**References:** Radiology, Boston Medical Center - Boston/US

**Fig 10.**
**Fig. 10:** A. US image showing two echogenic gallstones and sludge filled gallbladder, no definite signs of acute cholecystitis. B. Coronal contrast enhanced CT image of acute cholecystitis with pericholecystitic fluid, surrounding fat stranding, gallstones, and hyperemia demonstrated by hyperenhancement of the adjacent liver parenchyma. C. Axial T2 fat sat image showing acute choecystitis with pericholecystitic and perihepatic fluid, gallbladder wall thickening, and a large gallstone.

**References:** Radiology, Boston Medical Center - Boston/US

**Fig 11.**
Fig. 11: A. US image showing a normal appearing gallbladder. B. Coronal T2 TSE MRI showing a gallstone in the neck of the gallbladder. C. MRCP image showing a gallstone in the neck of the gallbladder, dilated common hepatic duct proximal to the stone and normal caliber common bile duct distal to the stone, consistent with Mirizzi's syndrome. This finding was not seen on the US.

References: Radiology, Boston Medical Center - Boston/US
Fig. 1: Acute cholecystitis diagnosed with ultrasound imaging demonstrating marked diffuse wall thickening and large echogenic shadowing gallstones.

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**Fig. 2:** Acute cholecystitis diagnosed on ultrasound showing distended gallbladder with pericholecystic fluid and layering sludge.

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Fig. 3: Axial (A) and coronal (B) images which show calcified gallstones and mild fat stranding surrounding the gallbladder.

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Fig. 4: A, B. Two ultrasound images of the gallbladder which show a thickened wall and possible submucosal shedding, concerning for gangrenous cholecystitis. C. Axial contrast enhanced CT showing diffuse marked submucosal edema of the gallbladder wall with central hyperenhancing mucosa, consistent with HIV cholangiopathy.

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Fig. 5: Coronal contrast enhanced CT image. There is air seen diffusely within the gallbladder wall diagnostic of emphysematous cholecystitis. In addition, there is infiltration of the surrounding fat and wall thickening in the adjacent bowel loop.

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Fig. 6: AP (A.) and lateral (B.) view of a positive HIDA scan showing non-visualization of the gallbladder and radio tracer within the small bowel.

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Conclusion

- Ultrasound will likely continue to be the initial modality used to evaluate right upper quadrant pain, however it does have limitations.
- CT also has limitations with diagnosis of cholelithiasis and acute cholecystitis, however, it can provide information relating to other abdominal pathology.
- MRI and MRCP not only provide increased sensitivity and specificity for diagnosis of acute cholecystitis compared to ultrasound, it allows for evaluation of the biliary system for choledocholithiasis and pre-operative planning.
- Rapid sequences, lack of ionizing radiation, and use of hepatobiliary agents may make MRI the next choice of imaging for diagnosis of acute cholecystitis when ultrasound is equivocal.


